



# PROBAD

Code-based Strength Calculations of Pressure Parts

SIGMA Ingenieurgesellschaft mbH

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## 1 The Program system PROBAD

### PROBAD *Code-based Strength Calculations of Pressure Parts*

PROBAD is the standard solution for code-based strength calculations of pressure parts. PROBAD is successfully used for years worldwide by leading companies of the boilers and vessels industry, in plant design and in piping construction.

The latest status of standards in PROBAD and a continuously technical development is guaranteed by PROBAD maintenance agreements.

PROBAD offers solutions for the effective use of calculation modules in accordance with the standards:

- AD 2000-sheets, TRD-sheets
- EN 12952, EN 13480, EN 13445, EN 1591
- ASME Sect. I., ASME Sect. VIII./1, ASME B31.1, ASME B31.3
- WRC 107, WRC 297

## 2 Highlights

Some highlights of these PROBAD calculation modules:

- PROBAD is of modular design; this enables licensing individual modules in relation to the company needs (see available PROBAD solutions).
- PROBAD allows not only re-checking defined component dimensions, but also designing or optimizing components.
- The comprehensive component databases of PROBAD include additional norms and standards regarding dimensions, wall thickness, tolerances etc.
- Material databases containing EN, DIN and ASME materials are supporting the calculation modules. The values can be edited or modified individually by the user.
- **Standard-safety factors of the calculation rules are stored** and can be modified in accordance with the projects requirements.
- For all PROBAD modules screen **inputs** and print outputs are currently available in German and English. The dialog system provides convenient help screens, either as text or graphic.
- PROBAD is continuously subject to technical **changes** and novelties as also for monitoring systems etc.
- Based on the various maintenance agreements, SIGMA GmbH is obliged to keep the solutions up to date by annual releases, so the PROBAD **modules** are always following the actual codes/standards.
- For PROBAD licensees with maintenance contract a **hotline** is available.

### 3 PROBAD - National Codes

#### 3.1 AD 2000 sheets, series B

- Cylindrical parts with up to 10 nozzles and their interactions under internal and external pressure **B1/B6/B9/B10**
- Pipe bends and elbows under internal and external pressure **AD-B1, App. 1**
- Conical parts (concentric and eccentric cones) with up to 10 nozzles and their interactions under internal and external pressure **B2/B1/B6/B9/B10**
- Dished ends and hemispherical heads with up to 10 nozzles and their interactions under internal and external pressure **B3/B1/B6/B9/B10**
- Flat round and square heads or plates with centered nozzle under internal and external pressure **B5**
- Welded and flanged tube sheets with or without marginal moment including tubes under internal and external pressure **B5/B1/B6**
- Dished covers under internal and external pressure **B4**
- Expansion joints under internal and external pressure (single bellows or unguided or guided intermediate tube) **B13**
- Flanges, single and pair, including bolts and gasket as welding-neck flanges, weld-on flanges, welding-neck stub, weld-on stub with loose ring or lap joint flanges for collars **DIN 2505+ B7/B8**

#### 3.2 AD 2000 sheets, series S

- Simplified analysis for cyclic loading **AD 2000 S1**
- Vessels with support skirts **AD 2000 S3/1**
- Horizontal vessels on saddles **AD 2000 S3/2**
- Vessels with dished ends on feet **AD 2000 S3/3**
- Vessels with support brackets **AD 2000 S3/4**

#### 3.3 TRD - Technical regulations for steam boilers (TRD)

- Cylindrical parts with up to 10 nozzles and nipples and their interaction **TRD 301**
- Cylindrical as Y-shaped branches **TRD 301**
- Cylindrical shells with up to 10 nozzles; optional calculation of combined cyclic changes; allowable rate of temperature change / allowable number of load cycle changes / fatigue analysis **TRD 301, App.1**
- Bended tubes and Elbows **TRD 301, App. 2**
- Spherical shells and dished heads with up to 10 nozzles and their interactions **TRD 303**
- Spherical shells and dished heads, optional calculation of combined cyclic changes; allowable rate of temperature change / allowable number of load cycle changes / fatigue analysis **TRD 303, App.1**
- Flat heads with central nozzle **TRD 305**
- Fire tubes under external pressure (straight tube with/without reinforcing pad, fire box and corrugated tubes) **TRD 306**
- Fatigue calculation based on the creep rupture strength for cylindrical shells, y-shaped form pieces and bended tubes and elbows **TRD 508**

## **4 PROBAD - European codes**

### **4.1 EN 12952 - Water tube boilers**

The PROBAD module "EN 12952 - Water Tube Boilers" provides the following components for strength calculations due to internal pressure and temperature:

- Cylindrical parts with up to 10 nozzles and nipple fields and their interactions
- Tees
- Cylindrical shells with Y-branches
- Pipe bends and elbows
- Square tubes with single openings and rows of holes in longitudinal direction
- Spherical shells and dished heads with up to 10 nozzles and their interactions
- Spherical shells with Y-branches
- Unstayed flat ends with centered nozzle
- Creep fatigue calculation for all items listed above
- Calculation of the fatigue strength due to cyclic internal pressure or combined cyclic changes due to internal pressure and temperature for cylindrical shells and spherical shells with up to 10 nozzles; optional calculation of the allowable rate of temperature change, the allowable number of changes for one load cycles, the determination of the usage factor or the equal temperature rate for all load cycles

### **4.2 EN 13480 - Metallic Piping**

The PROBAD module "EN 13480 Metallic Piping" provides strength calculations of the following parts under internal and/or external pressure:

- Cylindrical components with up to 10 nozzles and their interactions
- Tees
- Pipe bends and elbows
- Dished ends and hemispherical ends with up to 10 nozzles and their interactions
- Reducers (concentric and eccentric cones) with nozzles and their interactions
- Circular flat ends and plates with up to 10 openings
- Cylindrical shells with Y-branches
- Miter bends
- Simplified analysis for cyclic loading

### **4.3 EN 13445 - Unfired pressure vessels**

The PROBAD module "EN 13445 Unfired Pressure Vessels" provides strength calculations of the following parts under internal and/or external pressure:

- Cylindrical components with up to 10 nozzles and their interactions
- Tees
- Dished heads, hemispherical and spherical heads with nozzles and their interactions
- Reducers (concentric and eccentric cones) with nozzles and their interactions
- Flat circular, elliptical and square heads and plates with openings
- Tube sheets on heat exchangers
- Horizontal vessels on saddles or ring supports
- Vertical vessels with support skirts

## 4.4 EN 1591 - Flange connections

The PROBAD module "EN 1591 Flange Design" provides re-checking or designing of flanged joints in accordance with EN 1591.

For standard flanges in accordance with DIN, EN 1092-1, EN 1759-1, ASME-B16.5 and ASME B16.47A/B16.47B the dimensions of flanges, bolts and gaskets as well as clamping parts (washers, expansion sleeves, HYTORC discs resp. HYTORC expansion nuts) are stored in a database and can always be retrieved into convenient, easy-to-use input panels. Additionally it is possible to enter non-standard measures.

Available flange types:

- weld-on flanges, welding-neck flanges, slip-on flanges, put-in flanges with tube stopper, integral flanges, blind flanges, threaded flanges
- stub constructions with loose rings as weld-on stub, welding-neck stub, slip-on stub, put-in stub with tube stopper, integral weld-on stub, blind stub
- collar construction with loose rings as welding collars or as welding collar with long neck.

The usage ratios are determined by given loads like pressures, temperatures, forces and moments for:

- **flanges** considering the possibly connecting component (cylindrical, conical, spherical, hemispherical shell, dished head)
- **bolts**
- **gaskets** under consideration of gasket parameters acc. to EN 1591-2 or manufacturer defined parameters, published on [www.gasketdata.org](http://www.gasketdata.org).

Only one single calculation step is used to check the flange connection for the assembly condition and up to nine subsequent conditions.

Special verifications like nominal tighten torque, bolt forces, maximum flange rotation or minimum usage ratio of the bolts can be provided additionally.

## 4.5 EN- and DIN pipe series

The PROBAD module "DIN-/EN-Piping" provides serial calculations of standard pressure parts in piping systems for:

- straight pipes
- corresponding nozzle tables
- corresponding bended pipes
- elbows
- tees
- reducers
- caps
- flanges
- blinding plates

The calculation optionally can be carried out for internal pressure or external pressure according to

- EN 13480 (metallic industrial piping)
- EN 13445 (unfired pressure vessels)
- EN 12952 (water tube boilers)
- AD-2000
- TRD
- DIN 2413

As an alternative to the codes the selection of fittings may be carried out by integrated rating tables.

The analysis of flanges is provided by integrated P/T-Rating-tables (e.g. acc. to EN 1092-1).

## 5 PROBAD - ASME Codes

The input values and results can be done either in European or American units. The required pressure  $p'$  acc. to the Pressure Equipment Directive can be determined selectively.

### 5.1 ASME Section I - Power Boilers

The PROBAD module "ASME Section I." is used to calculate the strength of the parts under internal pressure:

- Cylindrical shells with up to 20 nozzles and up to 10 nipple fields and their interactions
- Dished ends and hemispherical ends with up to 10 nozzles and their interactions
- Flat circular and non-circular ends with centered nozzle

The required pressure  $p'$  acc. to the Pressure Equipment Directive can be determined if required.

### 5.2 ASME B31.1 - Power Piping

The PROBAD module 'ASME B31.1' includes the following parts for pipes under internal pressure in plant design and boilers industry:

- Straight tubes with up to 10 nozzles and their interactions
- Bent tubes and elbows

The materials can be selected in accordance with ASME B31.1, Appendix A, ASME II-D for ASME I or VIII.

### 5.3 ASME B31.3 - Process Piping

The PROBAD module "ASME B31.3" includes the following parts for pipes under internal pressure in petroleum refineries and chemical plants:

- Straight tubes with up to 10 nozzles and their interactions
- Bent tubes and elbows

The materials can be selected in accordance with ASME B31.3, Appendix A / K (High Pressure), ASME II-D for ASME I or VIII.

### 5.4 ASME Section VIII, Division 1 - Pressure Vessels

The PROBAD module "ASME Section VIII, Div. 1" provides strength calculations of the following parts under internal and/or external pressure:

- Cylindrical shells with up to 10 nozzles and up to 10 nipple fields and their interactions
- Conical shells and ends (concentric and eccentric cones) with up to 10 nozzles and their interactions
- Dished ends and hemispherical ends with up to 10 nozzles and their interactions
- Flat unstayed ends with centered nozzle
- Dished covers with flanges (spherical dished covers) under internal pressure
- Flanges, single and pair, including bolts under internal pressure
- Tube sheets for heat exchangers according to ASME for U-tube heat exchanger, fixed tube sheet heat exchanger and heat exchanger with immersed floating head and heat exchanger with externally or internally sealed floating head

The materials can be selected in accordance with:

- ASME II-D for ASME VIII.
- ASME II-D for ASME I.
- ASME B31.1, Appendix A
- ASME B31.3, Appendix A or Appendix K

## 5.5 ASME Pipe series

The PROBAD module "ASME Piping" permits the serial calculation of standard pressure parts under internal pressure in piping systems for

- straight pipes
- corresponding nozzle tables
- corresponding bended pipes
- elbows
- tees
- reducers
- caps
- flanges
- blinding plates

The calculation proof can be done optionally according to the codes:

- ASME Section I.
- ASME Section VIII. Div.1
- ASME B31.1 (Power Piping)
- ASME B31.3 (Process Piping)

As an alternative to the codes the selection of fittings may be carried out by integrated rating tables. The analysis of flanges is provided by integrated P/T-Rating-tables (e.g. acc. to ASME B16.5).

The input values and results can be done either in European or American units.

The required pressure  $p'$  acc. to the Pressure Equipment Directive can be selectively determined.

## 5.6 WRC

The modules PROBAD 'WRC 107' and 'WRC 297' are independent applications.

### 5.6.1 WRC 107 / WRC 537

The PROBAD module " WRC 107 / WRC 537" is required for calculating stresses resulting from local loads (forces or moments) on cylindrical shells (attachment forms: circular massive, square massive or tubular) and on spherical shells (attachment forms: circular massive and square massive).

Additionally the superposition of several individual load cases is possible, where the superposition also covers single stresses or internal pressure.

At cylindrical shells additionally stresses from internal pressure and bending moments acc. to ASME Section III Class 1 and 2. can be super imposed.

At tube plugs and nozzles an additional proof of the attachment both inside and outside of the intersection area can be requested.

### 5.6.2 WRC 297

The PROBAD "WRC 297" module provides stress analysis at nozzles in cylindrical shells and nozzles with or without pad reinforcement resulting from 3-axial forces or moments.

Types of calculation available in this module:

- Re-checking of existing geometries
- Design of the shell thickness- or nozzle and pad thickness
- Determination of allowable values of a force or moment component
- Stress analyses (local and global loads) are additionally provided in accordance with 'AD-S3/0', 'AD-S4', 'BS 5500' or by free input.



## 6 EN-/DIN material databases (FEZEN)

The material database FEZEN provides material properties for metallic materials for standardized materials acc. DIN- and EN-Material-Codes/Standards:

- Approximately 1.500 sheets containing material reference data basing on standard data of the EN material codes. Material data deviating from the above standards (revaluation or devaluation) are taken into account in line with EN 12952, EN 13480, EN 13445 and the AD-2000 and TRD codes.
- Approximately 700 material sheets with materials reference data based mainly on standard data of the DIN codes, but also on data of VdTÜV or SEW sheets. Material data deviating from the above standards (revaluation or devaluation) is considered following AD-2000 and TRD codes.

The EN-/DIN-database is used by the PROBAD-EN modules EN 12952, EN 13480, EN 13445, EN 1591, EN-DIN-pipe series, national codes calculation modules AD-2000 and TRD, as well as modules WRC 107, WRC 297 for the internal determination of relevant material values. That's why it is recommended to order a license of the EN-/DIN database together with the calculation modules.

Additionally a comparison of the new European material names according to EN 10027 and the old designations according to DIN 17006 and 17007 is available.

The material database FEZEN is revised permanently by SIGMA. Annual updates provide the latest strength values.

### 6.1 FEZEN information system for EN and DIN materials

The PROBAD module "FEZEN information system" provides the interactive use of the material databases for EN- and DIN-materials and is even working independent of PROBAD calculation modules. The program is used to recall material properties (individually or in total) and to print material sheets.

This module analyzes and shows characteristic values (tensile strength, yield strength or proof stress values, creep strength values etc.) as well as the components physical properties, allowable stresses, allowable temperatures and life cycle parameters

## 7 ASME- Material database

The PROBAD modules basing on ASME-Codes (ASME Sect. I, ASME B31.1, ASME B31.3, ASME Sect. VIII.) is connected to an ASME material database containing approximately 300 SA steels. Either the allowable stresses or stress values can be defined for a material on the input panels.

The ASME material database is revised permanently by SIGMA. Annual updates provide the latest strength values.

## 8 DLL-Interface solutions for the material databases EN, DIN and ASME

The material databases of EN- DIN- and ASME-materials can be integrated by an interface program in form of a DLL (dynamic link library) by customer's specific programs and allows the evaluated material data.

## 9 Licensing, system requirements and support

The program license is available as perpetual single user license or network license basing on the license conditions. Licensing a program requires the acceptance of the terms of use by signing a system contract. Contract samples are available upon request.

- Single user license installation or
- Network license server installation
- Licensing of all PROBAD modules by integrating DLL interfaces into a customer specific software solution.

<b>Single user license</b>	The single user license allows the installation of the program on the PC-systems of the licensee and the use by means of a license key (dongle) on one PC system simultaneously.
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<b>Network license</b>	The network license enables the access to the program system by any PC in the network, limited by the number of users.
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### License duration

<i>Time unlimited /perpetual license (purchase)</i>	Allows the <b>time unlimited use of the program</b> . Maintenance and user support are part of the maintenance agreement.
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### Scope of delivery and license key

The programs' scope of delivery contains

- the program data (by download including online manual)
- a license key (USB dongle)

The software does not run without the license key.  
New releases are unlocked by actualization of the license key.

### System requirements

The system requirements of all PROBAD program versions are as following:

#### System requirements of single user licenses and PC-workstations in the network

- Windows 10, 8 or 7
- Pentium processor, 32 MB Extended Memory, VGA graphic
- approx. 400 KB free RAM, up to 120 MB free harddisk space depending on the number of codes licensed
- USB connection for the license key

#### System requirements network server

- Installation of the license manager on a Server PC accessible by all users in the network.
- Windows 10, Windows 8, Windows 7 (32-/64-bit) Windows Server 2008/2012.

In case of integrating ROHR2 into company-wide or countrywide networks (WAN) please contact us.

## 10 Software Services

### **Maintenance, updates and user support**

The PROBAD maintenance contract includes user support, software updates and calculation code releases. PROBAD is equipped with a comprehensive software documentation (manual (online manual)). The support team assists the user in questions concerning the application of PROBAD in the daily work on the project. The direct link to the hotline guarantees an effective use of PROBAD and assures that you receive competent help in a timely manner.

**PROBAD**

continuously

**developed  
and  
updated**

Updating the software by periodical releases is an essential component of the maintenance agreement. The software is developed continuously in order to incorporate the ongoing changes in the calculation codes and norms, according to the user's needs. The technical regulations for the calculation of components are subject to a permanent change. These changes are monitored by our development team and implemented in the program system PROBAD in a timely manner. Updates are available via internet download.

This assures the user of PROBAD that the software always is updated to most recent editions and changes of the codes which are required by the legislator of the current norms and laws. The technical development in software programming as well as the adaption to technical prerequisites, such as operating systems, are also considered and part of the update service. This ensures a long-term safeguarding of the investment of soft- and hardware.

### **SIGMA Ingenieurgesellschaft**

SIGMA, established in 1989 in Dortmund, Germany has emerged as the partner of choice for leading international companies with its software and wide variety of engineering services. SIGMA is known as one of the leading engineering specialists in the Pipe Stress Business in Europe. SIGMA develops and distributes ROHR2, the European Pipe Stress software and SINETZ, Software for the analysis of pressure drop and heat loss in piping systems.

From 2017 on the development and distribution of the PROBAD engineering solutions will be led by SIGMA Ingenieurgesellschaft.

### **PROBAD Training**

SIGMA distributes PROBAD licenses and offers training units as well as workshops for calculation standards.

### **Software Development, Sales and Support**

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